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THE UTILIZATION OF PARASITES FOR REDUCING ORIENTAL FRUIT MOTH INJURY TO PEACHES

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INTRODUCTION

Of all the insect pests that attack the peach in the Eastern and Central States, the oriental fruit moth is the most difficult for the grower to deal with. Extensive efforts on the part of both State and Federal entomological agencies, since the discovery of this insect in the United States in 1916, have not yet resulted in the development of practical measures for its control that can be generally utilized by growers. In this situation, efforts to utilize more fully the natural enemies of the insect in its control have assumed unusual importance and are of special interest to commercial growers. This circular summarizes briefly current information about the parasites of the oriental fruit moth, what has been done about them, how they are being used, and the trend of investigations under way. Although the oriental fruit moth causes damage to several fruit crops, the only crop in which parasites are generally recognized as being valuable in checking injury is the peach. The subsequent discussion will be limited to the use of parasites in reducing injury to peaches.

HOW REDUCTION IN FRUIT INJURY IS PRODUCED BY PARASITES

Over a large portion of the area infested by the oriental fruit moth the principal damage to the main commercial varieties of peaches is caused by larvae of the third generation. This generation is preceded by two others which develop chiefly in the tender twigs. The fruit moth is able to reproduce itself in such large numbers that if the increase which might normally develop from the overwintering survivors in any locality is not checked before the eggs of the third, or fruit-infesting, generation hatch, an extremely heavy infestation of third-brood larvae develops in the ripening fruit. Fortunately, certain species of parasites destroy enormous numbers of twig-infesting larvae, and other parasites attack the eggs or the stages of the fruit moth in the cocoons. Even when weather and other conditions

are generally favorable to moth increase, the activities of parasites may reduce the numbers of larvae at harvest time below the numbers that were present at the beginning of the season. Under such conditions the fruit infestation will be relatively low.

For three successive years, from 1937 to 1939 inclusive, an effort was made by the Bureau of Entomology and Plant Quarantine to measure more exactly the effect of parasitism of the oriental fruit moth on the injury to peach fruit. The studies have included a series of 51 orchards in 11 more or less distinct peach-growing districts east of the Alleghenies, extending from Lovingston, Va., to Princeton, N. J., and supplement several less extensive surveys made by State experiment stations. It has been found that both the parasitism and the fruit infestation vary widely in different years, between different districts, and even between orchards in the same district, but in general within any district the orchards having the heaviest parasitism of twig-infesting larvae also have the lowest fruit infestation. This was particularly true for 1938 and 1939, in which years conditions other than parasitism in the districts surveyed were apparently favorable for moth increase. In 1938, in 6 orchards in the Virginia, West Virginia, and Maryland area which had parasitism in excess of 66.7 percent there was an average of only 3.2 percent fruit injury, as compared with an average of 25.5 percent injury in 8 orchards in the same area having less than 33.3 percent parasitism. In 1939 a group of 6 orchards in the same section with more than 66.7 percent parasitism had only 1.4 percent fruit injury, as compared with 19.2 percent injury in 11 orchards having less than 33.3 percent parasitism.

THE RELATIVE IMPORTANCE OF THE VARIOUS SPECIES OF PARASITES

Native parasites.--In the United States the fruit moth is attacked by more than 100 species of native parasites. No species is present in all orchards every season. Only a few species are generally abundant, but more than a dozen species are known to occur in abundance in some orchards every season. A few more occasionally become abundant enough to destroy a considerable portion of the fruit moths in some restricted districts. Of all these kinds of parasites, one species, named Macrocentrus ancylivorus Roh., has proved to be outstanding in effectiveness and in adaptability to a wide variety of conditions, and the greater part of the work connected with the utilization of parasites for oriental fruit moth control has involved this species.

Foreign parasites.--The Bureau of Entomology and Plant Quarantine has searched infested peach districts in Australia, Europe, and Japan for other promising species of fruit moth parasites. Twenty-nine such foreign species have been imported, propagated at Moorestown, N. J., and colonized widely over the infested area. The results have not been encouraging. Several of these introduced species produced high initial rates of parasitization, and at least two were able to persist in the locality of liberation

for 1 or 2 years following release, but, so far as known now, none have become estbalished. The work of importing, breeding, and liberating foreign species of parasites was discontinued in 1938.

WORK ACCOMPLISHED WITH THE PARASITES OF THE ORIENTAL FRUIT MOTH

Parasites may be liberated for either of two purposes. The first purpose is the establishment of a parasite species in an area in which it does not occur. In such cases a small number of parasites are placed in an already infested orchard, and if they succeed in establishing themselves, they are expected utlimately to increase in numbers to the maximum possible under the conditions existing in the orchard, and also to spread into other orchards in the locality. Most of the work of this Bureau from 1930 to 1936 was on this basis. When the parasites are well adapted to conditions existing in a given locality, they continue to function year after year as valuable crop protectors, destroying enormous numbers of fruit moths each season, without any effort being made on the part of the growers or others inter ested inprotecting the peach crop.

The second purpose for which liberations may be made is to obtain a reduction in injury to fruit the same season. Since 1936 an increasing amount of attention has been given to the possibility of effecting immediate control of the oriental fruit moth through the mass liberation of parasites. Since the purpose of mass liberations is to increase immediately and greatly the numbers of the oriental fruit moth destroyed by parasites over the whole area included in the liberations, the manner of making the liberations differs considerably from that of liberations made for the purpose of establishment of the parasites.

Colonization of parasites of the oriental fruit moth.--In 1929, early in the study of the parasites of the oriental fruit moth, the distribution of Macrocentrus ancylivorus was found to be limited to a few counties in central Connecticut, southern New Jersey, Delaware, and eastern Maryland. A program of rearing and releasing this parasite was, therefore, undertaken. From 1930 to 1935, the period when most of this work was accomplished, the Bureau of Entomology and Plant Quarantine reared and, in cooperation with several State agencies, liberated about 132,000 adults of this parasite in 402 colonies well distributed throughout the infested area from Massachusetts to Michigan and south to Georgia and Arkansas. This work is being continued on a much reduced scale as additional counties in outlying States become infested with this pest. In addition the Bureau has collected and shipped nearly 700,000 strawberry leaf roller and fruit moth larvae containing this parasite to cooperating State stations to assist them in rearing and colonizing additional supplies of Marcocentrus.

As a result of this work Macrocentrus ancylivorus soon became established in many of the principal peach - growing districts from Connecticut west to Michigan and south to Georgia and Arkansas. Its establishment has been followed in most instances by a high rate of parasitism and a decided reduction in fruit infestation. In some districts in which this parasite has become dominant there have been instances of the recurrence of moderate fruit infestation, but none are known in which the pest has been able to duplicate the heavy damage caused by it in the early days before M. ancylivorus became established.

Experiments with liberation of parasites for immediate control.--Experiments in the mass liberation of parasites conducted for 4 successive years in orchards of southern New Jersey have been moderately encouraging. Macrocentrus ancylivorus has been used in these liberations at the rate of approximately 500 per acre. In most cases these liberations have been followed by an increase in parasitism, a decrease in the number of moths emerging, and substantially lower fruit injury in the orchards receiving the parasites. The average fruit injury in the orchards receiving parasites was about 50 percent less than that in those not receiving parasites, and 22 of the 25 orchards receiving parasite liberations have had less fruit injury than that occurring in the check orchards. In Burlington County, in 1939, the five orchards receiving parasites had an average of 34 injured fruits per tree, which was about one-fifth the injury in the check orchards not receiving liberations. Mass liberations of M. ancylivorus have been tried in sections where the species released was already dominant and also in districts where it was not abundant. The results were similar in both cases.

Mass liberations of Trichogramma minutum, a common native egg parasite, were made during two successive years at the rate of about 50,000 parasites per acre. No substantial reduction in fruit injury was observed following the liberation of Trichogramma.

Production of Macrocentrus for liberation.--During the last few years much progress has been made in the large-scale production of M. ancylivorus. There are several ways in which this parasite can be bred or reared for use in liberations. In southern New Jersey the best results have been obtained by breeding the parasite in large field cages of aster cloth erected over strawberry. The caged strawberry plants are heavily stocked with strawberry leaf rollers, and later on with parasite adults. A few days later the parasitized leaf rollers are removed to rearing cages, from which the parasites that develop are assembled for liberation as they emerge. The principal problems encountered in this procedure have been difficulty in carrying enough leaf rollers and parasites over winter to stock large parasite-breeding cages, and trouble in holding strawberry pests such as the red spider in check during the process of breeding in the field cages. These difficulties have now largely been overcome. A propagation rate of 10-fold is not unusual, and enough parasites can be produced from an acre of strawberry under cage for mass liberations over 1,200 acres of orchard. The prop-

agation of these parasites requires a certain amount of equipment and entails a considerable degree of experience and skill in the manipulation of the material. The technique of producing them is not at the present time suitable for adoption by individual peach growers, unless the services of individuals experienced in parasite production are available.

POINTS TO BE CONSIDERED IN PLANNING AND MAKING PARASITE LIBERATIONS

Thus far Macrocentrus ancylivorus is the only known oriental fruit moth parasite liberations of which have been frequently followed by beneficial results. In orchards in which the species does not occur, liberations for the purpose of establishment are advisable unless experience with similar liberations during previous years in the same orchard or in other orchards of that district indicates that M. ancylivorus is unsuited to that environment. Fortunately there appear to be few localities in the infested area unsuited to this parasite. When the purpose of the liberation is establishment, a colony of 100 lively, mated females should be sufficient. (A female Macrocentrus can be readily distinguished from the male by the presence of the ovipositor, a slender structure, about as long as the rest of the insect, which protrudes from the tip of the abdomen.) They should be released when plenty of worms are available for them to attack. Usually the best time for release is in June or July when the larvae of the second brood of the fruit moth are present in freshly wilted twigs of the peach. In some sections moderately heavy twig infestations on peach trees after harvest, or the presence of some other insect such as the strawberry leaf roller which this parasite is known to attack during the periods when orinental fruit moth larvae are not available in twigs, make it feasible to release later than July. At present it is difficult to obtain this parasite in large numbers to be available for colonization earlier than the middle of June.

The Bureau of Entomology and Plant Quarantine of the United States Department of Agriculture does not have the facilities to produce parasites of the oriental fruit moth for general distribution to individual growers Several agricultural experiment stations, however, are producing such parasites for liberation within the borders of their respective States, and limited supplies of Macrocentrus ancylivorus can now obtained from commercial sources.

When mass liberations for immediate control are being considered ,the number of parasites that should be liberated is an important consideration. The use of large numbers per unit of area increases the cost and the difficulty of obtaining the necessary parasites. It is obvious, however, that if the number liberated is lowered beyond a certain point, the reduction in infestation which could be produced by the parasites during the short period between their release and fruit harvest would be negligible. Approximately 500 parasites per acre have been used in the experiments conducted by the Bureau of Entomology and Plant Quarantine. It would be perhaps be economically feasible to use more than this, and, on the other hand, possibly a slightly

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smaller number would have given nearly as satisfactory results. From available information, however, it seems rather unlikely that liberations of less than 100 parasites per acre would cause a substantial reduction in fruit injury. If only one shipment is to be received, the parasites used in mass liberations should be released at or just before the peaks of first-brood or second-brood infestations of oriental fruit moth larvae in peach twigs. If large numbers are being liberated and successive shipments can be arranged, it is advisable to make several liberations in each block, starting as soon as freshly wilted twigs with young larvae are observed and continuing them for about 2 weeks. Macrocentrus ancylivorus released after a majority of the second-brood larvae have completed their feeding in twigs could not possibly reduce fruit injury caused by the following brood. Proper timing is therefore highly important. Since only female parasites can attack the oriental fruit moth worms, the parasites released should contain a satisfactory proportion of that sex. Only vigorous, active adults should be used, and the degree of mortality noted in the cages at the time of liberation is a fair indicator of vitality. Units in which the mortality among females is in excess of 10 percent would be considered relatively unsatisfactory for mass liberations. In most of the material used in the experimental work described above, the mortality of females at the time of liberation was less than 1 percent.

Parasites shipped for liberation must be handled with great care to prevent high mortality or loss of vitality. Macrocentrus does most of its work at night, in twilight, or on cloudy days. It is sensitive to extremes of heat or dryness, and the adult lives for only a few days in midsummer. In transporting it to the orchard, the containers should be kept cool and damp, which can be done by wrapping them in a clean wet blanket or by placing them in a wooden box with ice. The packing should be done in such a way that water from the melted ice will not seep into the parasite containers. "Dry ice," or solid carbon dioxide, should never be used to keep parasites cool, since the gas generated would kill the insects. If possible, the parasites should be released on the day of arrival, though preferably not during the hours of excessive midday heat. They can be released in moderate rain if the adults are active enough to fly to protection on the under side of the leaves.

SUMMARY

In the absence of any other practical measure for the control of the oriental fruit moth that can be utilized by growers, a determined effort is being made to utilize more fully the natural enemies of this insect in its control. Parasitic insects destroy great numbers of the oriental fruit moth and are particularly valuable in reducing the infestation at the time of harvesting the main commercial varieties. Many foreign species of parasites have been imported, but their colonization

in the United States has not been successful. In the United States the fruit moth is attacked by more than 100 species of native parasites. Of these, one species named Macrocentrus ancylivorus is outstanding in effectiveness and in adaptability to a wide range of conditions, and can be manipulated to increase the total of parasitism in orchards infested with the oriental fruit moth.

The colonization of Macrocentrus ancylivorus for the purpose of establishment has been most successful. As a result of this work, Macrocentrus ancylivorus has become established as the most valuable parasite of the fruit moth in many of the principal peach-growing districts from Connecticut west to Michigan and South to Georgia and Arkansas. The work of colonization is being continued by several State agencies within the borders of their respective States, and by the Bureau of Entomology and Plant Quarantine in the more recently infested areas. Experiments in the mass liberation of Macrocentrus ancylivorus during the last 4 years have been moderately encouraging, the average fruit injury in the orchards treated being only about half as heavy as in the orchards not treated. Much progress has also been made in developing methods for large-scale production of this parasite. It is now possible to produce enough parasites under one acre of field cage to make mass liberations over 1,200 acres of peach.

Growers who are expecting to make liberations of Macrocentrus in their orchards should consider whether such liberations are to be made for the purpose of establishment or for the immediate reduction of the infestation. They should also try to deliver parasites to the orchards in vigorous condition, and to make their liberations at a period suitable for maximum effectiveness of the colonization.

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